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A commercial software package, the Osiris School Administration System, is proposed to assist schedulers in developing schedules for students, instructors and classrooms. The software's capability is demonstrated on a smaller scheduling problem and its potential application to the NPS problem is analyzed.

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ANALYZING NPS SCHEDULING USING OSIRIS

by

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B. S. Electrical Engineering, Marquette University, 1984

Submitted in partial fulfillment
of the requirements for the degree of

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This thesis addresses a known problem in class scheduling at the Naval Postgraduate School (NPS). The problem is the lack of an automated system capable of generating schedules for each academic quarter. This results in two Class Schedulers developing schedules manually through a trial-and-error process which takes approximately six weeks to complete.

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C.1

TABLE OF CONTENTS

I. INTRODUCTION 1

A. NAVAL POSTGRADUATE SCHOOL 1

1. Students and Faculty 1

2. The Scheduling Problem 2

B. THESIS PURPOSE AND ORGANIZATION 3

C. OSIRIS SCHOOL ADMINISTRATION SYSTEM 3

II. BACKGROUND ON SCHEDULING 4

A. EARLY HISTORY 4

B. CURRENT SCHEDULING PROCESS 5

1. Forecasting 5

2. Pre-Scheduling 6

3. Scheduling 6

4. Post-Scheduling 7

C. AUTOMATION EFFORTS 7

1. Heuristic Academic Master Scheduler 7

2. Heuristic Model 8

3. FOCUS 9

4. On-Line Course Catalog 9

D. RECENT RESEARCH 9

1. Naval Postgraduate School Scheduling Support System 10

2. Naval Postgraduate School Scheduling System 11

III. SCHEDULING WITH OSIRIS 12

A. PRELIMINARY INFORMATION 13

1. Calendar 13

2. Databases 15

a. Student Information 16

b. Teacher Information 17

c. Course Information 18

B. INITIALIZING THE SCHEDULER 20

C. ENTERING STUDENT REQUESTS 20

1. Importing Requests 21

2. Optical Scanning 21

3. Manual Entry 22

4. Automatic Course Selection Rules 22

5. Combination 23

D. BUILDING CLASS SECTIONS 23

E. CREATING THE MASTER SCHEDULE 24

1. Master Schedule Screen 24

2. Conflict Matrix 25

3. Blocking 26

4. Section Assignments 27

F. SCHEDULING STUDENTS 27

1. Course Scheduling Rules 28

2. Class Loader 28

3. Resolving Conflicts 28

G. SCHEDULER REPORTS 29
1. Preliminary Reports 29
2. Class Load Analysis Reports 30
3. Final Reports 32

IV. CONCLUSIONS AND RECOMMENDATIONS 33

APPENDIX A: PRELIMINARY REPORTS 35

APPENDIX B: CLASS LOAD ANALYSIS REPORTS 40

APPENDIX C: FINAL REPORTS 47

LIST OF REFERENCES 53

INITIAL DISTRIBUTION LIST 54

LIST OF FIGURES

Figure 1 NPS Scheduling Phases 5

Figure 2 Osiris Scheduling Process 12

Figure 3 Scheduler Preliminary Information 14

Figure 4 Osiris Calendar Screen (Career Day) 14

Figure 5 Osiris Calendar Screen (NPS) 15

Figure 6 Student Information Record 16

Figure 7 Teacher Information Record 18

Figure 8 Course Information Record 19

Figure 9 Original Master Schedule Screen 21

Figure 10 Updated Master Schedule Screen 25

Figure 11 Conflict Information 26

I. INTRODUCTION

A. NAVAL POSTGRADUATE SCHOOL

The Naval Postgraduate School (NPS) was established to serve the advanced educational needs of the Navy. The school's purpose is to increase the combat effectiveness of the Navy and Marine Corps by providing post-baccalaureate degree programs in a variety of subspecialty areas not found in other academic settings. Under the direction of the Chief of Naval Operations, the emphasis at NPS is on research programs which are relevant to the Navy's interests and those of the other branches of the Department of Defense. The school's programs exceed graduate degree requirements as the requirements of the military services determine the scope of each program. The school strives to maintain superior levels of instruction, to be responsive to fleet innovations, and to prepare its students to introduce and use future technologies. [Ref. 1]

1. Students and Faculty

Nearly 2000 students attend NPS. Officers from the five U.S. armed services and approximately 25 allied nations make up the student body. Students are chosen to attend NPS based upon superior professional performance and a strong academic background. [Ref. 1]

Student interaction with the diverse faculty is stressed at NPS. There are no teaching assistants - each class is taught directly by a faculty member, over 99% of whom have Doctorate degrees. [Ref. 1]

2. The Scheduling Problem

The school year at NPS is divided into four quarters. Each academic quarter consists of eleven weeks of course work, followed by a one-week period for final examinations. Schedules for classes and examinations are developed independently and primarily through the manual efforts of two class schedulers. Preparing the schedules for an academic quarter requires full-time work from the schedulers during most of the previous quarter.

The scope of the scheduling problem at NPS is enormous. Each quarter over 200 professors must be scheduled to teach more than 300 courses to almost 2000 students in approximately 100 classroom and laboratories. More than most schools, NPS tries to tailor course offerings to student requests. It is the job of the schedulers to fit these requests into a master schedule for the entire school. Recurring events such as departmental meetings must be included. Instructor requirements and preferences for certain days, time periods and/or classrooms add numerous constraints to the problem. [Ref. 2]

B. THESIS PURPOSE AND ORGANIZATION

The purpose of this thesis is to analyze the feasibility of the NPS Class Schedulers using a commercially-available academic scheduling program to significantly reduce the amount of manual labor required to produce the quarterly schedule of classes. The proposed software package is the Osiris School Administration System, which will be introduced in the next section.

Chapter II will review the history of NPS scheduling. Previous attempts and current proposals to automate the process will be discussed. Chapter III will detail the operation of Osiris and propose NPS applications. In Chapter IV, conclusions and recommendations are presented.

C. OSIRIS SCHOOL ADMINISTRATION SYSTEM

The Osiris School Administration System is a commercial software package designed to allow school administration to be performed on a small network of personal computers. Osiris contains modules used to record data and produce reports for attendance, course grades, and class schedules. The powerful scheduling module is designed to save weeks of time usually spent creating a master schedule manually. [Ref. 3]

Before an application at NPS was considered, Osiris was being applied to a local scheduling problem at Monterey High School. Its scheduling function displayed many obvious improvements over the manual scheduling system at NPS.

II. BACKGROUND ON SCHEDULING

Course scheduling at NPS is better described as an art form than as a science. Successful academic schedulers generally possess superior organizational skills and an in-depth knowledge of scheduling techniques, plus experience in applying these techniques. NPS relies on the skills and experience of the Class Schedulers to create the academic schedule each quarter. The schedulers can balance conflicting demands only with a thorough knowledge of the school and its staff.

A. EARLY HISTORY

In its early days, NPS retained 65 civilian faculty to instruct 370 students in one of three component schools. The Engineering School, the Management School and the General Line and Naval Science School each developed their schedules independently between 1951 and 1958.

The position of Schedule Coordinator was created to allow schedules to be developed centrally by a faculty member. The need for centralization evolved from the growth of the student and faculty populations and from increased instructor overlap between the three schools.

As the school continued to grow, the magnitude of the scheduling problem detracted from the Scheduling Coordinator's

performance as a faculty member. In 1965, the Schedule Coordinator was replaced by two full-time civilian Class Schedulers. To this day, the Class Schedulers have passed down the techniques used to create the NPS academic schedule from one scheduler to the next. [Ref. 4]

B. CURRENT SCHEDULING PROCESS

The four phases of the scheduling process at NPS are shown in Figure 1.

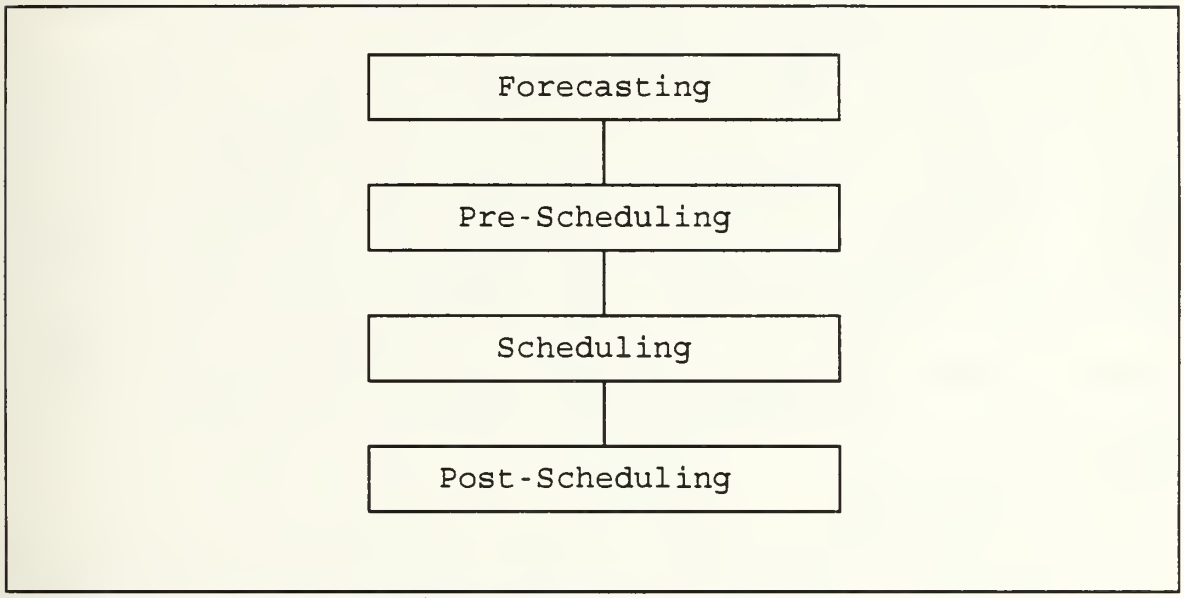

Figure 1 NPS Scheduling Phases

1. Forecasting

Forecasting is one of the duties of the Management Analyst and is the phase least relevant to the Class Schedulers. Up to a year in advance, probable quarterly student course demands are projected with the related instructor workloads. The Management Analyst runs a forecast

program to merge current student files with estimated new student course demands. This results in a tentative course schedule showing which courses are expected to be taught during each quarter by each academic department. [Ref. 4]

2. Pre-Scheduling

The Pre-Scheduling phase is a quarterly process in which scheduling data is gathered to construct the academic schedule. It takes place during the first four weeks of the quarter prior to the one being scheduled and has the tightest time schedule of the four phases.

During the Pre-Scheduling phase students request courses and the academic departments determine which courses will be taught. Students then replace any requests for courses which are not being offered and the academic departments divide large courses into segments and assign instructors to each course. [Ref. 4]

3. Scheduling

During the Scheduling phase, the information gathered during the Pre-Scheduling phase is used by the Class Schedulers to build a comprehensive course schedule and individual schedules for students, instructors and classrooms. Students are assigned to course segments and the Class Schedulers select meeting times and classrooms for the lecture and laboratory components of each segment.
[Ref. 4]

4. Post-Scheduling

In the Post-Scheduling phase, information is derived from the schedules to be used in the Forecasting phases of later quarters. Also, the Class Schedulers register and coordinate any changes to a course's classroom or meeting time. The Class Schedulers do not monitor changes in individual student schedules. [Ref. 4]

C. AUTOMATION EFFORTS

Solving roster-type academic scheduling problems was first attempted in 1951. Throughout the years, there have been several attempts to automate some or all of the scheduling process at NPS. The greatest success is evident in the Forecasting and Pre-Scheduling phases, which are nearly completely automated.

1. Heuristic Academic Master Scheduler

Between 1962 and 1966 Roland J. Payne and Jean Bow developed the Heuristic Academic Master Scheduler (HAMS), a computer program designed to build a master schedule for the school. HAMS was written in the SCRAP (Symbolic Coded Relocatable Assembly Program) assembly language for the school's CDC 1604 computer and closely followed the clerical rules observed by the human scheduler while generating a schedule. Using the computer under flexible human control, HAMS generated a master schedule for classes and for final examinations. [Ref. 5]

Although HAMS could produce a schedule comparable to one generated manually, there were several reasons it was never implemented. First, HAMS was unable to schedule up to ten percent of all courses and its schedule left little room for these courses to be added manually without changing the entire schedule. Also, NPS was replacing its mainframe computer in 1967 and HAMS would have had to have been re-programmed. Finally, scheduling student aviators for flights to retain proficiency, a large part of HAMS, was no longer required when the flight program at NPS was eliminated in the late 1960s. [Ref. 6]

2. Heuristic Model

Dietmar Fiegas, an NPS student in Operations Research, took a heuristic approach to the scheduling problem in 1985. Fiegas realized that the Class Schedulers relied on personal experience, and his approach was to combine their knowledge of the school system with the speed and power of a computer.

Fiegas developed a FOCUS questionnaire to automate the collection of course scheduling constraints from the course instructors. His Master's Thesis presented a viable final examination schedule which he had generated, plus an automated system for data collection. However, Fiegas was unable to apply his approach to successfully solve the academic quarter scheduling problem. While many of his ideas have merit, none of Fiegas' work is in use at NPS.

3. FOCUS

Several database management programs were written at NPS in the FOCUS database language between 1985 and 1987. These programs remain in use for curricular offices to enter student and course information into the mainframe computer through remote terminals, successfully automating much of the Pre-Scheduling phase. FOCUS is also used to automatically print the schedules created by the Class Schedulers, freeing them from the manual typing they had done until 1988. [Ref. 4]

4. On-Line Course Catalog

Management analyst Hans Dolman automated the NPS course catalog in 1988. This allows greater student access to more current course information than is possible with the published catalog. The automated catalog is used by the Class Schedulers as their standard source of course information.

D. RECENT RESEARCH

Two Master's Theses dealing with improving the NPS scheduling process through automation were published in 1992. Significant involvement of human operators in automated scheduling systems is supported enthusiastically in both documents. Osiris also emphasizes the decision-making abilities of its users and provides scheduling data for the decision-maker.

1. Naval Postgraduate School Scheduling Support System

Jeffrey S. Nolan and Phillip D. Youngblood combined on a thesis proposing a decision support system to assist the Class Schedulers in developing quarterly schedules. Their proposal was the Naval Postgraduate School Scheduling Support System (NPS^4), which they believed would make schedule construction easier and more efficient than the current, primarily manual process.

In NPS^4, mathematical models are created to define portions of the scheduling system. More importantly, scheduling rules which are not easily translated into mathematical models are left for the user to apply. Nolan and Youngblood felt that automated measures would never completely solve the scheduling problem and that the NPS Class Schedulers are an irreplaceable part of the scheduling process. For this reason, they selected a partly automated decision support system to eliminate inefficiencies in the scheduling process. [Ref. 4]

Nolan and Youngblood did a great deal of research into NPS scheduling history and problems present in the process. However, they proposed that their system be implemented on a network of Macintosh computers, making it incompatible with the computers used in the NPS scheduling process [Ref. 7].

2. Naval Postgraduate School Scheduling System

Richard C. Dowler later reinforced Nolan and Youngblood's work. The goal of his thesis was to conduct a more detailed analysis of NPS^4, making it compatible with the installed network of computers. Dowler developed the Naval Postgraduate School Scheduling System (NPS^3), a database management system designed to assist the Class Schedulers by creating scheduling priorities for classes.

Dowler also realized the importance of maintaining a human element in the NPS scheduling process. NPS^3 would automatically schedule semipermanent events and present classes to be scheduled in prioritized order. The Class Schedulers assign meeting times, instructors and classrooms, and NPS^3 assists in conflict resolution. After any conflicts have been resolved, NPS^3 updates student, instructor and classroom schedules before the next highest priority class is scheduled. [Ref. 8]

Dowler was providing the background information for a joint thesis. His co-author began to implement their ideas, but the project remains incomplete. [Ref. 7]

III. SCHEDULING WITH OSIRIS

The Scheduler is an add-on module of the Osiris School Administration System designed to produce academic schedules for students and teachers. The Scheduler interacts with the System Administrator and the Database Editor, two Osiris base modules [Ref. 9]. The Osiris scheduling process is shown in Figure 2.

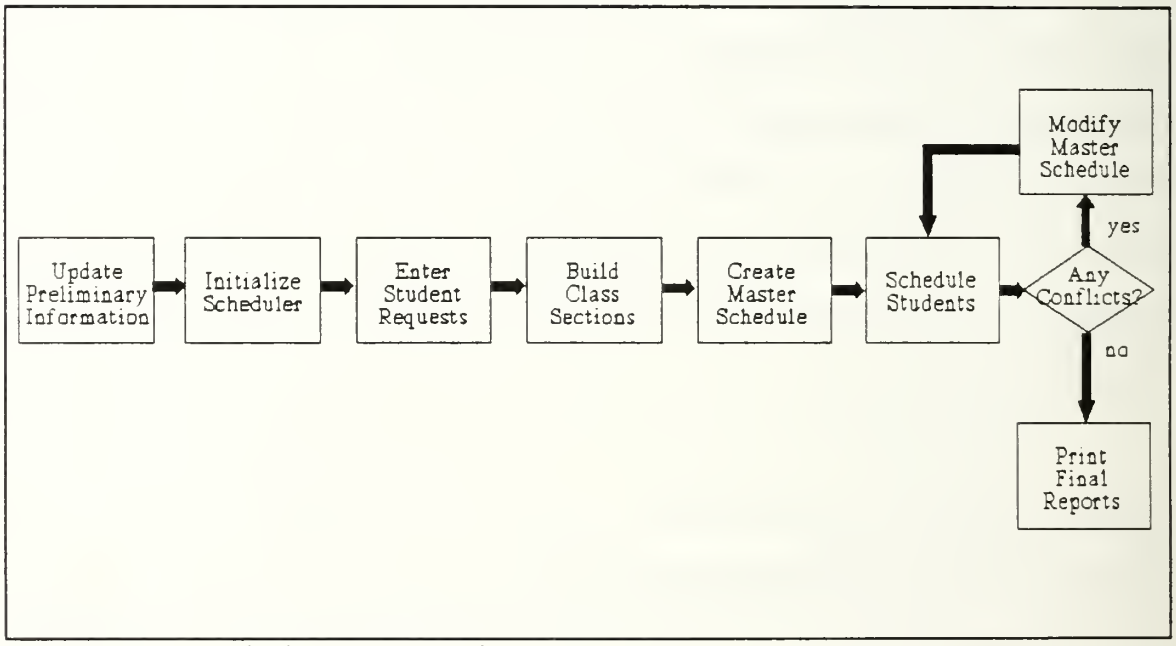

Figure 2 Osiris Scheduling Process

Another add-on, the Data Exchange module, may be used with the Scheduler to transfer data between Osiris and other computer programs. This capability was used to transfer NPS

student, instructor and course information from ASCII-format FOCUS files into the respective Osiris databases.

Unfortunately, student course request information is not handled by the Data Exchange module. The Scheduler contains its own data exchange capability, but this is limited to importing and exporting Osiris files between two computer systems running the Osiris software.

This shortcoming created the need to find another test school as a data source. Monterey High School had the Osiris software package available and requested assistance in scheduling students for lectures during its annual Career Day. With over 1500 students, Monterey High has a student body similar in size to that of NPS, and had student request information coded for optical scanning into Osiris.

A. PRELIMINARY INFORMATION

Figure 3 demonstrates the preliminary information accessed by the Scheduler to generate academic schedules.

1. Calendar

The calendar used for scheduling Career Day consisted of one four-period day, shown in Figure 4. This is much simpler than an NPS scheduling term, shown in Figure 5, which consists of 11 five-day weeks of nine-period days. The Osiris calendar is flexible enough to handle both of these cases and can also be used for schools which rotate class meeting times.

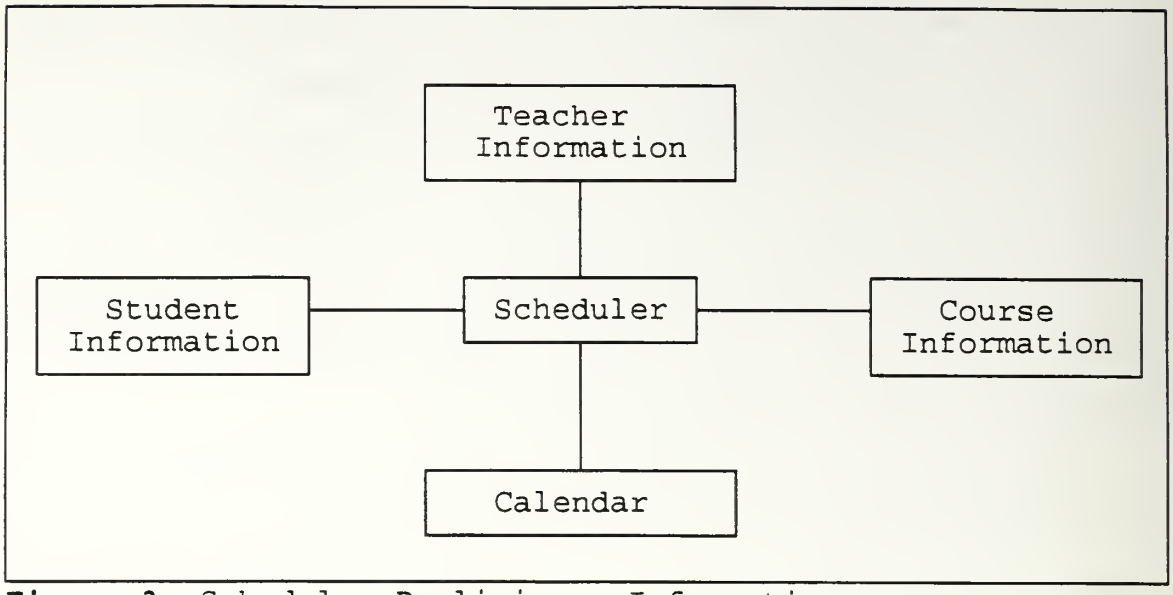

Figure 3 Scheduler Preliminary Information

The required calendar information is easily entered into Osiris in a matter of minutes.

Calendar Wednesday Mar 17, 1993

School Year: 92 (1992-93)

	Term Name	Starts	Ends
1	Career Day	3/ 5/93	3/ 5/93
2			
3			
4			
5			
6			

Days in Week(MTWRFSU): F

Days in Schedule Cycle: F

No. of Periods in Day: 4

Period Rotation (Y/N): N

School Calendar

Mar 5 Friday schoolday 1 F Att

Edit Times Rotation Non-School AttendanceDay GoTo Clear Print

Figure 4 Osiris Calendar Screen (Career Day)

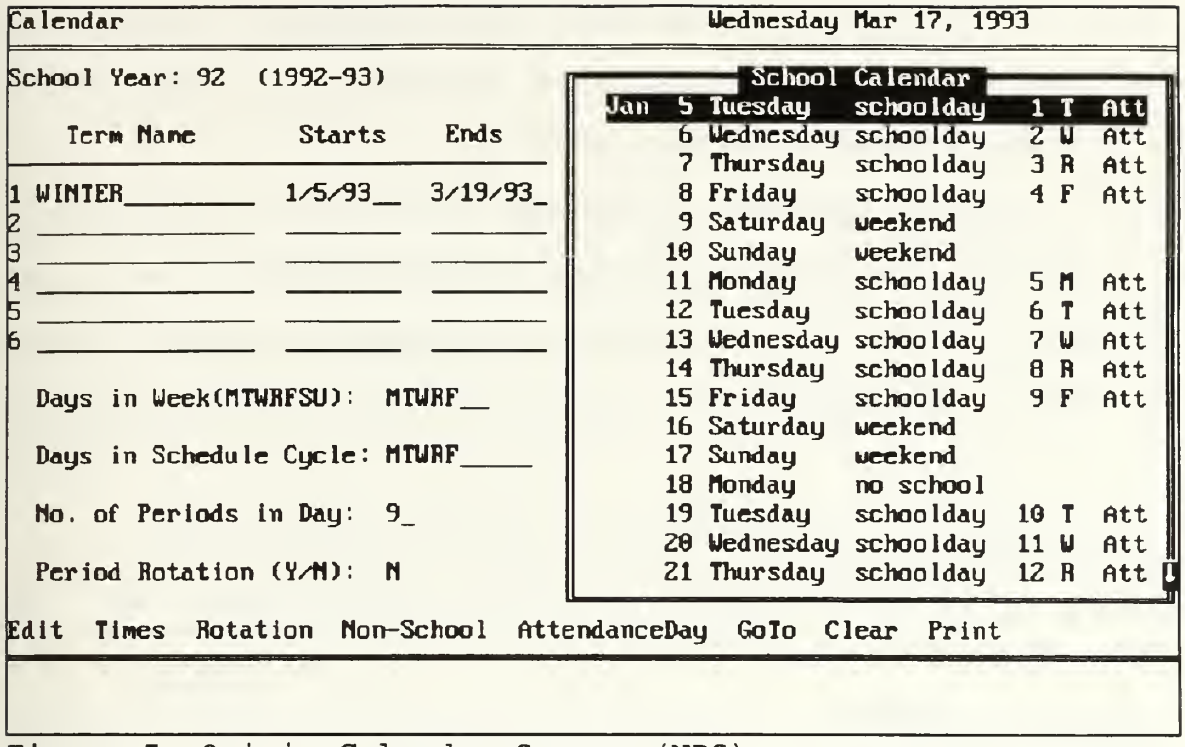

Figure 5 Osiris Calendar Screen (NPS)

2. Databases

Osiris maintains separate databases for student, teacher and course information. Each of the databases may be customized to meet record-keeping requirements, but only the entries relevant to scheduling will be discussed.

Three methods may be used to create or add to Osiris databases. As mentioned earlier, the Data Exchange module was used with the NPS data. Data may also be entered manually, or by using scan forms and an optical scanner.

For the Career Day scheduling problem, the preliminary databases contained records for 1541 students, 140 available instructors and 107 different course offerings. Although there was no database for classrooms, a room list was built

later in the scheduling process. Approximately 60 Monterey High classrooms were available for Career Day.

a. Student Information

The Scheduler accesses information about each student from the Database Editor. Each record may contain a significant amount of personal data, but only a limited amount is used during scheduling. A Monterey High student record is shown in Figure 6.

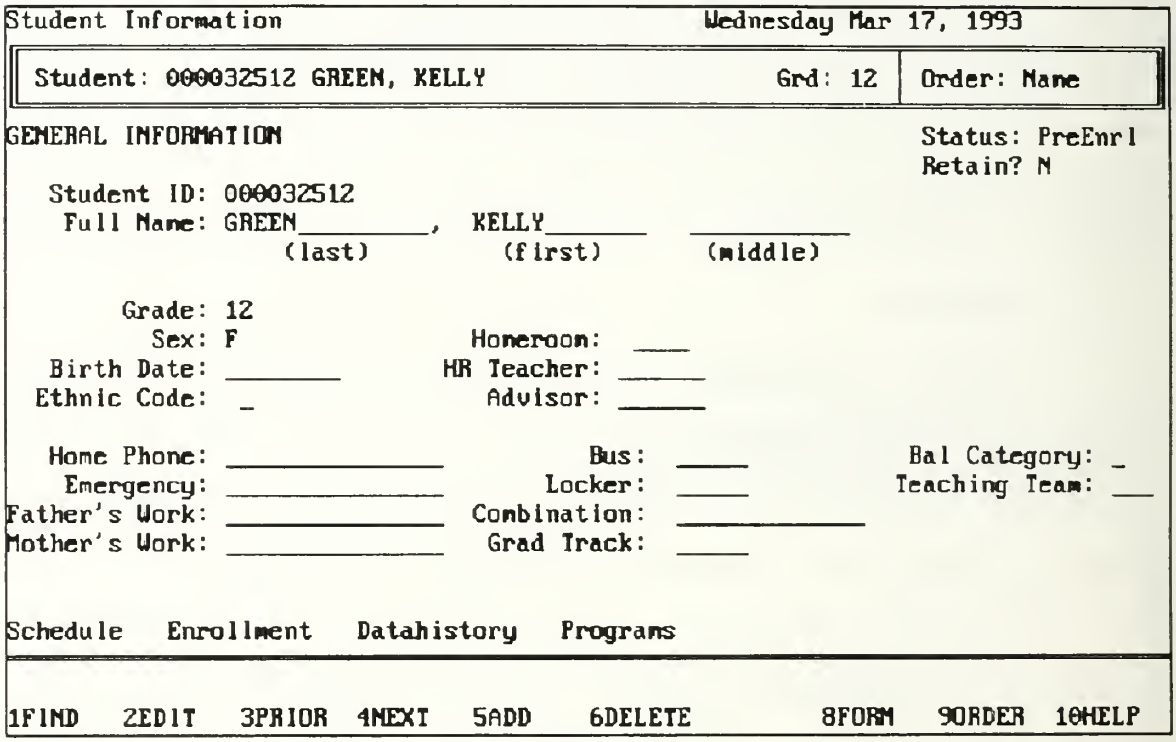

Figure 6 Student Information Record

Each student record must contain a unique student identification number, up to nine digits in length. Other required entries include first and last name, grade level and sex. An entry is included to indicate whether the student

should be retained or promoted at the end of the current school year.

For use at NPS, the student names and identification numbers were easily imported from the FOCUS database. Other record entries not directly related to scheduling, such as sex and grade level, can be set to default values. This was also done for the Career Day problem to simplify building the database.

b. Teacher Information

Information about each active teacher is copied from the database into scheduling files to be used during class scheduling. A teacher record is shown in Figure 7. Again, only a limited amount of the information capable of being stored is relevant to scheduling.

Each teacher must be assigned an identification number no more than six digits long. The teacher's first and last names are required entries, as is an indicator of whether the teacher is considered to be in an active or inactive status. Inactive teachers are not scheduled.

At NPS, the FOCUS database does not contain a suitable identification number for teachers. A number coded from each instructor's departmental code can be generated to use. An optional four-digit field in each Osiris teacher record can be used to associate the teacher with a particular department.

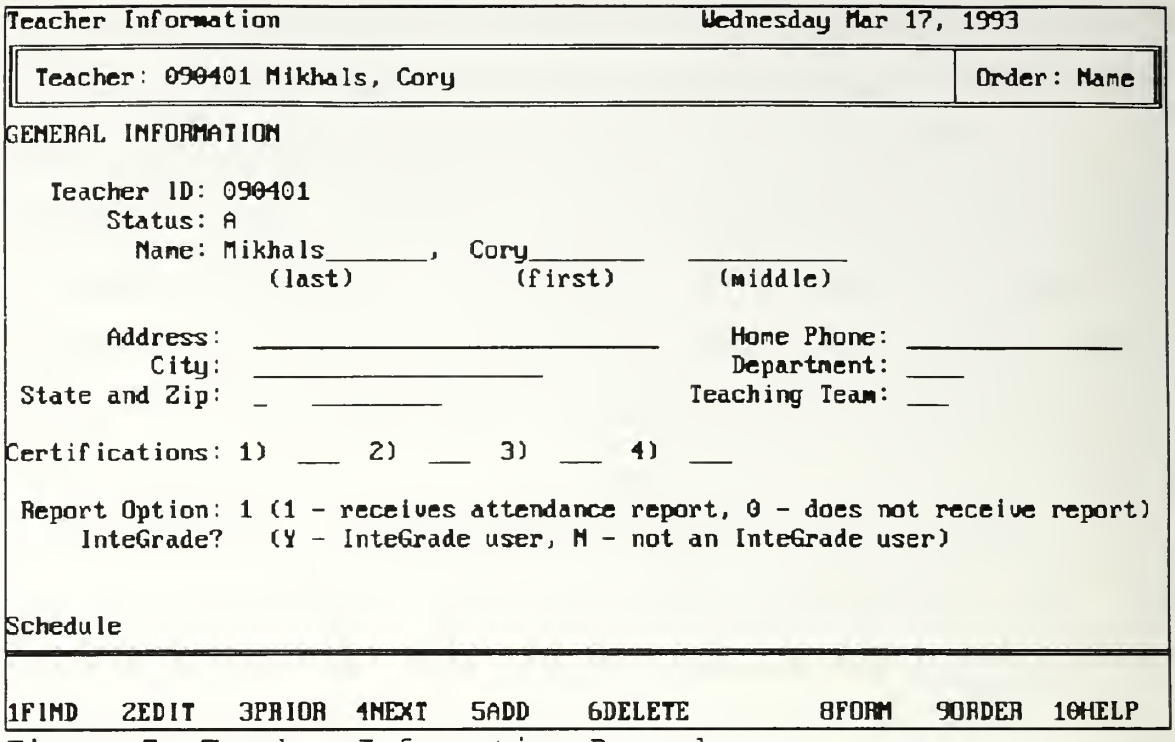

Figure 7 Teacher Information Record

c. Course Information

During initialization of the Scheduler, information about each active course will be copied into scheduling files. A course information record is shown in Figure 8. Each course must be identified by a six-digit number, which is not completely compatible with the NPS two-letter, four-digit numbering system. Again, use of numeric departmental codes would be required. A course name abbreviation field holds eight characters and could be used to identify courses in the traditional alphanumeric manner. An optional four-digit department field is also available.

The course information records also contain fields to indicate the maximum number of sections (called segments at

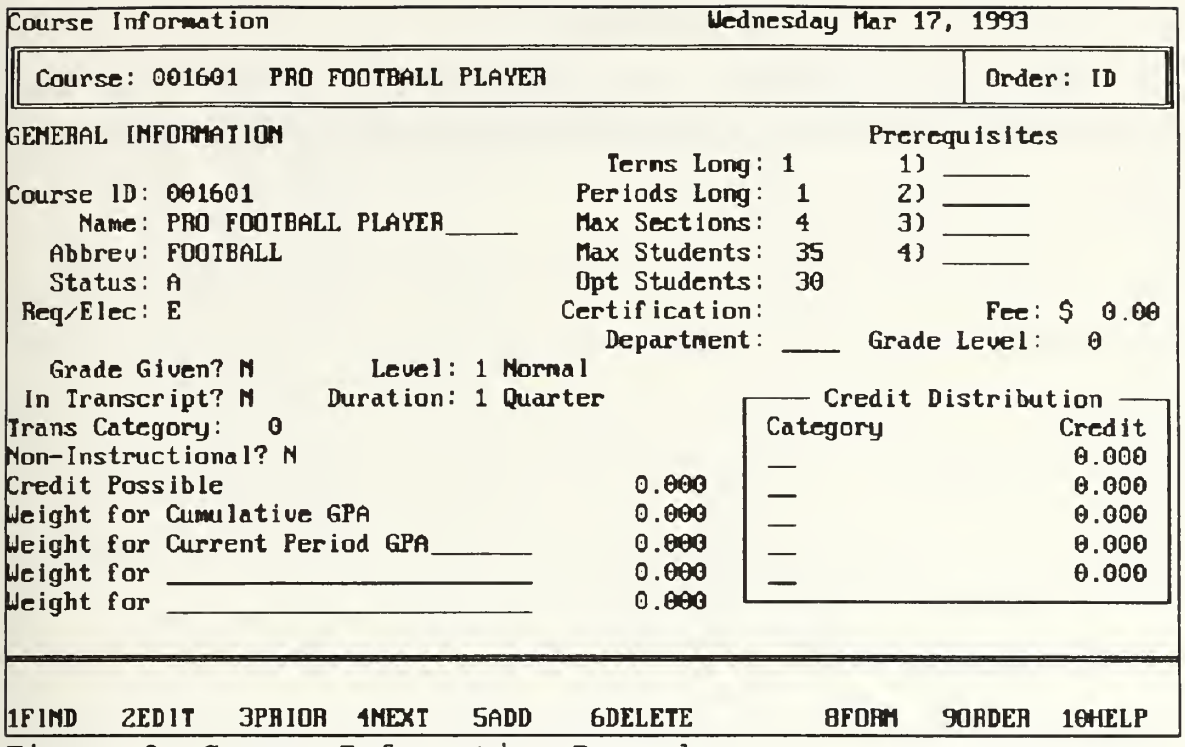

Figure 8 Course Information Record

NPS) to be scheduled and the maximum and optimal number of students to be scheduled into each section. Segments at NPS are generally limited to no more than 30 to 35 students.

The field indicating whether a course is required or an elective is not useful in an NPS application as the same course will have a different classification for different students. The Periods Long field also limits scheduling flexibility. This field is used to indicate the number of consecutive periods that a course meets in a day. At NPS, some course segments are scheduled for different lengths than other segments of the same course. The user can customize the lengths of various segments when creating the Master Schedule.

B. INITIALIZING THE SCHEDULER

After the calendar and database information has been updated, the next step in the Osiris scheduling process is to initialize the Scheduler.

During initialization, teacher and course information is copied into the Scheduler's files. Student information is not copied, but is accessed directly from the student database when necessary. A separate set of files is created, allowing scheduling of the next academic cycle to begin without affecting the current schedule.

The Master Schedule is first visible after initialization. As shown in Figure 9, the only information it displays at this stage is the course numbers, abbreviated names and the number of consecutive periods the course meets in a day.

C. ENTERING STUDENT REQUESTS

After the Scheduler has been initialized, student requests for courses may be entered. This section will examine the four methods of entering these requests. Requests may be imported from another Osiris system through the Scheduler's data exchange function, optically scanned using the DataScan module, entered manually, or Automatic Course Selection Rules may be applied.

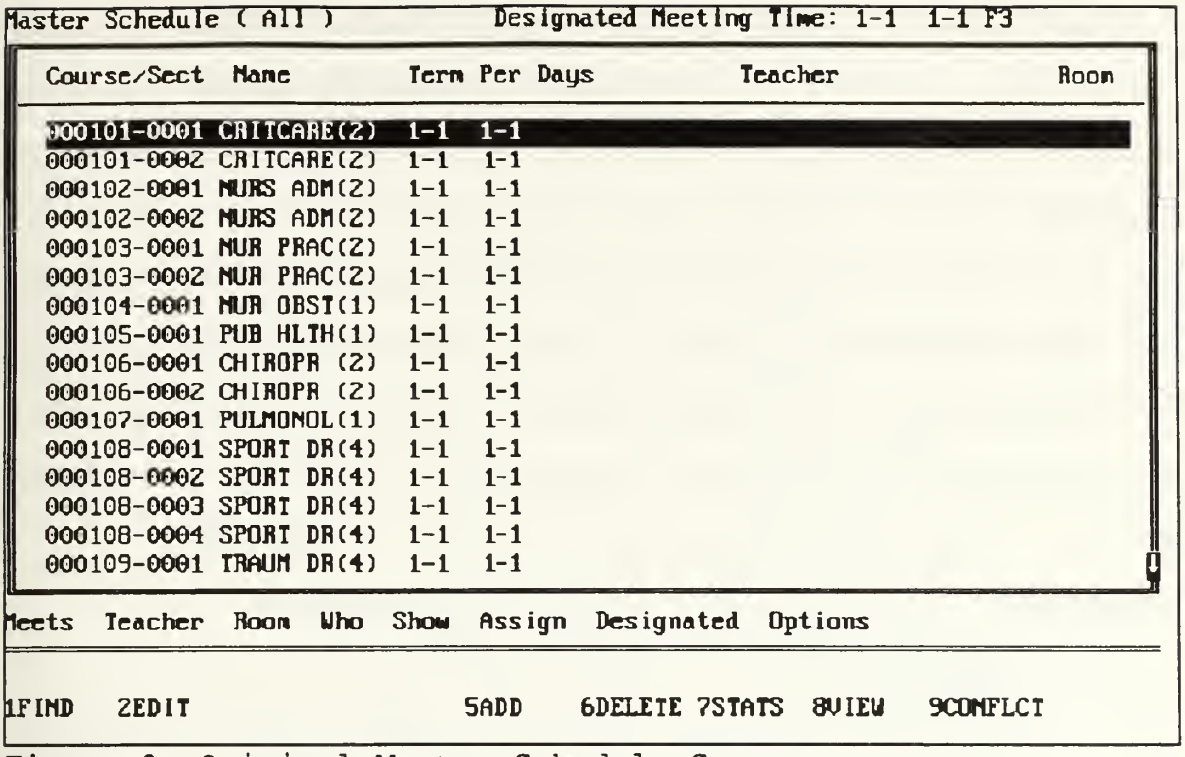

Figure 9 Original Master Schedule Screen

1. Importing Requests

The Scheduler's data exchange function is not compatible with non-Osiris files and is not considered to be useful in any NPS application.

2. Optical Scanning

The DataScan module was used to enter student requests for Career Day and could be applied at NPS using the Scantron Optical Mark Reader currently used to read Student Opinion Forms. Osiris is also compatible with NCS scanners.

Scan forms were filled out for 1327 Monterey High students, serving as a test for a later scheduling run when scan forms would be available for all of the students. Students selected four career lectures to attend, plus two

alternate selections to replace any choices which could not be scheduled. These courses and the associated student identification number were coded onto a scan form for each student.

At NPS, alternate course selections would not be made. The requests entered into Osiris would not be the original course requests, but would indicate the courses each student was registered for at the completion of the Pre-Scheduling phase. Each curriculum office would be responsible for submitting valid request forms for its students.

3. Manual Entry

In lieu of scanning request forms, requests could be manually entered into Osiris by each department. Corrections to invalid student requests for Career Day were made manually and could also be done in the NPS application.

4. Automatic Course Selection Rules

Automatic course selection rules are used to define course requests for a specific group of students. This capability was not used in the Career Day application, but would be valuable to NPS users.

Based on user-defined selection criteria, all students meeting those criteria would be given the same course request or set of requests. This would allow a department to easily enter requests for an entire section of its students. The automatic course selection rules would be particularly useful

during students' first few academic quarters when an entire section takes the same core courses.

Another useful tool is the ability to define exceptions to the rules. "If Also Taking" is an exception which automatically generates a request for a second course whenever a designated request is entered. At NPS, requests for lab segments could be generated by simply requesting designated courses which require an associated lab period.

5. Combination

The optimal application at NPS would involve a combination of these techniques. The automatic course selection rules would be used by the school to relate lab segments to lectures and by each department to quickly enter requests for groups of students requesting identical courses. Departments would enter the remainder of their requests manually or through the scanner to complete the process.

D. BUILDING CLASS SECTIONS

Building class sections is the next step in the scheduling process. This divides students requesting the same course into sections small enough to be taught by a single teacher. The Scheduler determines the number of sections to offer for each course based on the number of student requests, the maximum number of sections for that course, and the optimal number of students per section.

At NPS the number of sections to offer for each course is determined in the Pre-Scheduling phase. To allow Osiris to automatically build that same number of sections, the user is able to view the number of student requests for the course and may modify the optimal number of students per section. Sections may also be manually added or deleted in the Master Schedule screen.

E. CREATING THE MASTER SCHEDULE

In this stage of the scheduling process the user assigns a meeting time, instructor and classroom to each section in the Master Schedule.

1. Master Schedule Screen

At this point the Master Schedule screen displays each class section, the number of sections offered for each course, the period lengths for these sections and the days the section meets. This is shown in Figure 10. The user may schedule certain sections to meet for a different number of periods in a day than other sections of the same course, a measure of flexibility not available through the course database. The days each section meets will default to the full scheduling cycle (Monday through Friday at NPS) unless modified by the user.

In addition to displaying and modifying section information, the Master Schedule screen can be used to display potential schedule conflicts, as shown in Figure 11. This

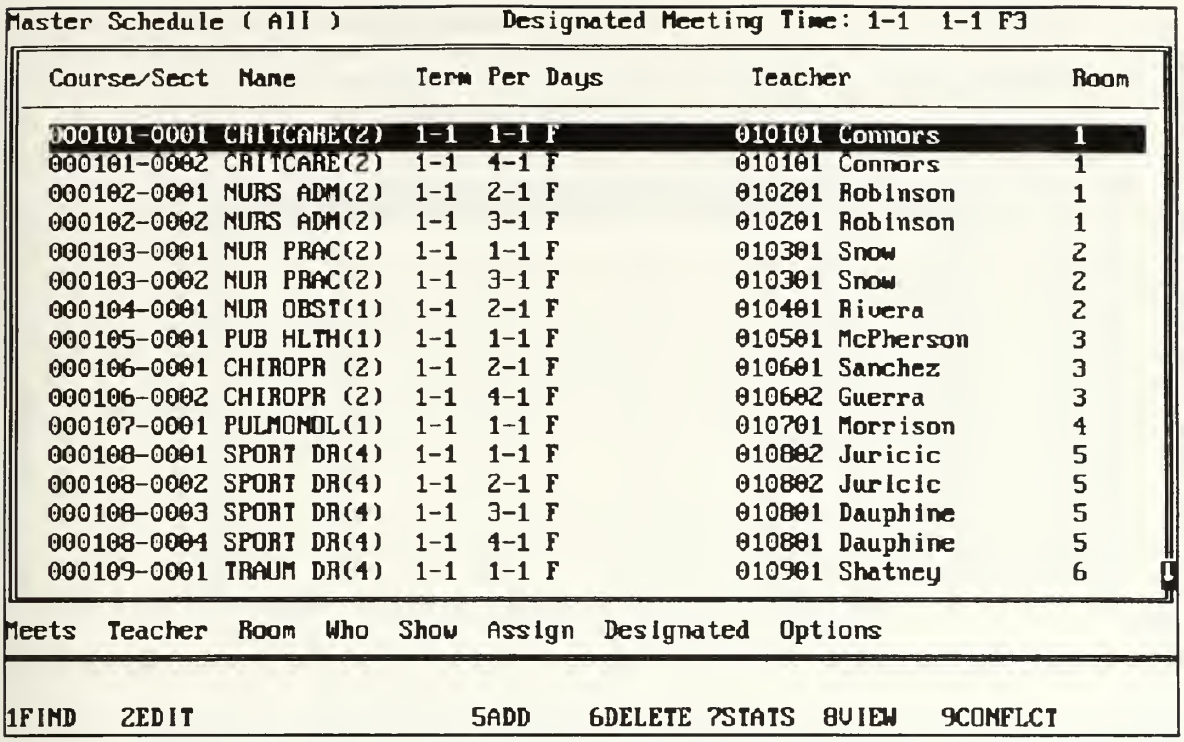

Figure 10 Updated Master Schedule Screen

allows the user to assign meeting times which minimize the number of potential conflicts. Conflict information is available after the Conflict Matrix has been built.

2. Conflict Matrix

If desired, Osiris will build a Conflict Matrix to allow the user to access information about potential schedule conflicts while assigning meeting times to sections. The Conflict Matrix is a list of pairs of courses which would create a conflict if scheduled to meet during the same period.

The Conflict Matrix would allow the NPS Class Schedulers to easily determine which class sections should be scheduled for different periods. In addition to the conflict

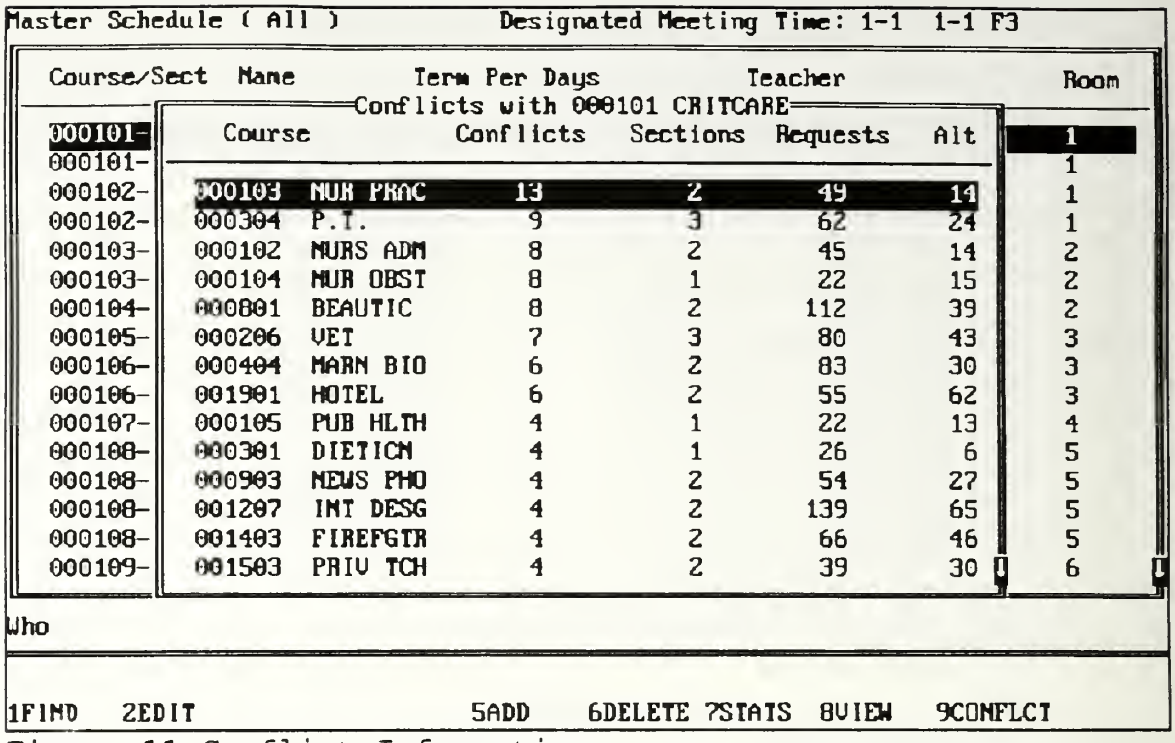

Figure 11 Conflict Information

information available in the Master Schedule screen, the Conflict Matrix can be printed in its entirety for easy access by the scheduler.

3. Blocking

Blocking prevents the user from assigning students, teachers and rooms to classes during certain periods or days. Blocking student or classroom schedules (for departmental lectures or meetings) could be of use, but the ability to block teacher schedules is a more valuable feature for NPS. Entering these blocks into the system would free the Class Schedulers from having to monitor the numerous requests received from instructors.

4. Section Assignments

Meeting times, rooms and teachers are generally assigned together. In order for Osiris to monitor classroom usage without a database, the user must build a room list by entering each room into the system. Although somewhat tedious, this allows the Scheduler to display a list of rooms and teachers available as the user chooses a meeting time for each section.

The conflict and balance information available on the Master Schedule screen would greatly assist the NPS Class Schedulers in selecting meeting times for class sections. For each day of the week, the screen displays by period the projected number of student schedule conflicts the selected section has with other sections scheduled during that period, the projected number of students scheduled during that period and any teacher or room conflict. Releasing the Class Schedulers from paper and pencil recordkeeping during this trial-and-error stage of the scheduling process is the most powerful advantage offered by Osiris.

F. SCHEDULING STUDENTS

Students are scheduled for classes by defining course scheduling rules and running the Class Loader. Afterward, student schedule conflicts are reported to the user for resolution.

1. Course Scheduling Rules

Course scheduling rules define relationships between certain requested courses. Most of the rules are not applicable when scheduling each term individually, but two related rules could be used at NPS. The Same Section As rule would tell the Scheduler to keep an entire lecture section intact when scheduling its students for the associated lab period. The Same Teacher As rule then schedules the same teacher for both the lecture and the lab.

2. Class Loader

The Class Loader eliminates the manual tasks usually required when scheduling students for classes. It automatically assigns students to classes based on the scheduling rules that have been imposed by the user. The class-balancing feature attempts to evenly distribute students among sections of a course.

3. Resolving Conflicts

The Class Schedulers minimize potential schedule conflicts by accessing conflict information when meeting times are selected for class sections. After the Class Loader has been run, the number of students which Osiris was unable to completely schedule is displayed.

The Student Schedule Conflict Report lists by student all class conflicts and the reasons for the conflict. Each student's schedule, including conflicts, may also be accessed

individually. After reviewing this data and the Conflict Matrix information, the user resolves schedule conflicts by modifying the days and/or periods which a section is designated to meet in the Master Schedule screen. The Class Loader is run again, and this process continues until a satisfactory Master Schedule is produced.

G. SCHEDULER REPORTS

Osiris produces a series of reports which may be used throughout the scheduling process. A Master Class List, class rosters and schedules for students, teachers and rooms are also generated. The reports which would be useful in an application at NPS are described in this section.

1. Preliminary Reports

The preliminary reports are useful during the early stages of scheduling. These reports provide information about student course requests, potential schedule conflicts and restrictions for teacher, room and student schedules. Examples of preliminary reports developed for Career Day are contained in Appendix A.

The Course Tally Report provides the total number of students requesting each course. The user then decides how many sections to build for each course. At NPS, this information is currently available and is used by the academic departments to divide courses into segments.

The Course Request Verification Report also duplicates currently used information. It lists each student's requested courses and allows the departments and/or students to verify that requests have been entered properly.

Osiris also produces a roster of students requesting each course called the Course Request Roster Report. The same information is used by the NPS Class Schedulers to manually build the quarterly schedule.

The use of the information provided in the Conflict Matrix Report was discussed earlier in this chapter. This information would greatly assist the Class Schedulers in assigning meeting times to course sections.

Student, Teacher and Room Schedule Blocks Reports are also available. Consolidation and automation of the teacher data would be a significant improvement over the current system in which these restrictions are maintained manually. Student and room schedule blocks were not used, so samples of these reports do not appear in Appendix A.

2. Class Load Analysis Reports

Seven class load analysis reports are available. Examples of each are contained in Appendix B. These reports give the analytical data associated with each run of the Class Loader. This information is used in schedule conflict identification and resolution.

The Class Load Report lists the total number of students scheduled into each course section. It also indicates the teacher assigned and the meeting time and days for each section. The number of open seats remaining for each class section is displayed with a size comparison between sections of each course.

Information about teacher schedule loads is presented in the Teacher Load Report. This report tells how many classes and students are taught by each teacher, in addition to the maximum number of classes the instructor is scheduled to teach consecutively.

The Student Schedule Conflict Report lists which students were not completely scheduled due to conflicts. The unscheduled courses are indicated, allowing the user to quickly determine where changes should be made in the Master Schedule.

Students who have more or less than a specified number of either course requests or courses scheduled can be displayed by the Student Schedule Exceptions Report. This report gives the student's name and identification number, plus the numbers of courses requested, courses scheduled and requests unscheduled for each student.

Student, Teacher and Room Free Period Reports are available. The student and teacher data can be used to determine whether courses are distributed adequately throughout the school day.

3. Final Reports

The final reports summarize the results of the scheduling process. Appendix C contains an example of each final report. The Master Class Schedule and individual schedules for students, teachers and rooms are generated. The Master Class List and class rosters are also produced.

The Master Class List and Master Class Schedule are similar except for the order in which class information is presented. Both reports indicate teacher and room assignments, the number of students assigned and meeting days and time for each course section. The Master Class List is ordered by course identification number, while the Master Class Schedule is ordered by class meeting time.

The Class Roster Report lists the name and ID number for each student assigned to a particular class section. Teacher name, room, number of students and meeting days and time are also provided.

The Student Schedules, Teacher Schedules and Room Schedules Reports provide the scheduling results for each student, teacher and room. The student and room schedules generated are similar to those currently used at NPS.

IV. CONCLUSIONS AND RECOMMENDATIONS

Although the current system for constructing quarterly schedules at NPS has been used for many years, there are obvious areas which could be improved. An automated scheduling system would greatly benefit the Class Schedulers by providing and maintaining scheduling information during the trial-and-error steps of schedule construction.

The Osiris School Administration System has demonstrated that it could be used to improve NPS scheduling. It employs the expertise of the Class Schedulers and could be implemented parallel to the current system. Still, several areas of further research exist in this field.

While the feasibility of using Osiris was shown by scheduling the Monterey High Career Day, Osiris has not yet been proven capable of solving the NPS scheduling problem. An implementation parallel to the current system should be tested during a scheduling cycle to reveal any potential limitations.

The background work done by Nolan, Youngblood and Dowler should not be ignored in attempting to improve NPS scheduling. The implementation of their ideas remains incomplete.

Other commercial software scheduling packages should be investigated. In addition to Osiris, CTB MacMillan/McGraw-Hill also produces another school administration package

called The School System. This package uses a different scheduling module which might be practical.

Finally, the scheduling methods used at other academic institutions should be investigated. Although these facilities may not use a system driven by student requests to the extent which NPS does, their software might be adaptable to the NPS problem.

APPENDIX A: PRELIMINARY REPORTS

Monterey High School

COURSE TALLY REPORT

Course	Description	Total	Alt	Grade 12	Grade 11	Grade 10	Grade 9
000101	CRITICAL CARE	39	13	39	0	0	0
000102	NURSING ADMINISTRATOR	45	14	45	0	0	0
000103	NURSE PRACTITIONER	49	14	49	0	0	0
000104	OBSTETRICAL NURSE	22	15	22	0	0	0
000105	PUBLIC HEALTH NURSE	22	13	22	0	0	0
0000106	CHIROPRACTOR	53	20	53	0	0	0
000107	PUMONOLOGIST	17	10	17	0	0	0
000108	SPORTS MEDICINE	127	47	127	0	0	0
000109	TRAUMA SURGEON	107	41	107	0	0	0
000201	DENTIST	58	15	58	0	0	0
000202	DENTAL HYGIENIST	27	11	27	0	0	0
000203	HOSPITAL ADMINISTRATOR	29	9	29	0	0	0
000204	OPTOMETRIST/OPTICIAN	14	5	14	0	0	0
000205	ORTHODONTIST	20	14	20	0	0	0
000206	VETERINARIAN	80	43	80	0	0	0

Monterey High School

REQUEST VERIFICATION REPORT Date: 2/17/93

Name	Courses	Credit	Comments
ABBOTT, E	000103 NUR PRAC	0.000	
	000404 MARN BIO	0.000	
	001802 AIR TRAF		Alt to 000404
	000602 FIN SVCS	0.000	
	001207 INT DESG	0.000	
	001301 ATTRNY		Alt to 001207
	Total Credit	0.000	

Monterey High School

COURSE REQUEST ROSTER REPORT Date: 3/18/93

Student ID	Name	Grade	Comment
000108	SPORTS MEDICINE		
000022696	AIELLO, V	12	
000037873	AINUU, MARIE	12	Alt to 000109
000007185	ALTAMIRANO, M	12	
000031286	AQUINO, A	12	
000025004	ARNOLD, T	12	
000011977	ATTALLAH, A	12	
000026704	ATWELL, M	12	
000006782	BACLER, A	12	
000023405	BAJPAI, ABHISHEK	12	
000032443	BAKER, ANTHONY	12	
000031025	BARNES, DERRICK	12	
000031026	BARNES, DEWAYNE	12	
000036623	BARRY, D	12	
000007582	BENISHEK, M	12	
000032395	BERRING, J	12	
000033982	BIXLER, J	12	
000017801	BOND, J	12	
000029379	BONDI, R	12	
000038178	BROCCHINI, A	12	

Monterey High School

CONFLICT MATRIX REPORT Date: 2/19/93

Course	Name	Conflicts	Sections	Requests	Alt
000101	CRITICAL CARE		2	39	13
000103	NURSE PRACTITIONER	13	2	49	14
000304	PHYSICAL THERAPIST	9	3	62	24
000102	NURSING ADMINISTRATOR	8	2	45	14
000104	OBSTETRICAL NURSE	8	1	22	15
000801	BEAUTICIAN	8	2	112	39
000206	VETERINARIAN	7	3	80	43
000404	MARINE BIO./ANI. HUSB.	6	2	83	30
001901	HOTEL MANAGEMENT	6	2	55	62
000105	PUBLIC HEALTH NURSE	4	1	22	13
000301	DIETICIAN	4	1	26	6
000903	NEWSPAPER PHOTOGRAPHERS	4	2	54	27
001207	INTERIOR DESIGNER	4	2	139	65
001403	FIREFIGHTER	4	2	66	46
001503	PRIVATE SCHOOL TEACHER	4	2	39	30
001603	GOLF CENTER MANAGER	4	1	15	6
001803	NAVAL TEST PILOT	4	2	107	66
000203	HOSPITAL ADMINISTRATOR	3	1	29	9
000204	OPTOMETRIST/OPTICIANS	3	1	14	5

Monterey High School

TEACHER SCHEDULE BLOCKS REPORT Date: 2/19/93

Name	ID	Term	Days	Period 1234
Adragna, Joe	170401	1	F	xx
Agrawal, Brij	120101	1	F	xx
Almquist, Allen	030301	1	F	xx
Armanasco, David	070301	1	F	xx
Babcock, Jim	180201	1	F	xx
Bartell, Nancy	110102	1	F	xx
Bates, Dennis	040101	1	F	xx
Bebermeyer, Robert	130104	1	F	xx
Bell, Barbara	180301	1	F	xx
Bowhay, Brooks	110901	1	F	xx
Bowman, Dennis	030701	1	F	xx
Brewer, Christine	030302	1	F	xx
Bronson, Jack	180401	1	F	xx
Brown, Karen	110701	1	F	xx
Canepa, David	170501	1	F	x xx
Carter, M. L.	160102	1	F	xx
Chambliss, Sandy	100201	1	F	x x
Chandler, Peggy	080301	1	F	x x
Chapman, Mike	160201	1	F	xx

APPENDIX B: CLASS LOAD ANALYSIS REPORTS

Monterey High School

CLASS LOAD REPORT Date: 2/20/93

Course	Sect	Subject	Meets	Teacher	Tot	Rem	Dif
000101	0001	CRITCARE	1-1 1-1 F	Connors	21	14	
	0002		1-1 4-1 F	Connors	18	17	
			TOTAL		39	31	3

Monterey High School

TEACHER LOAD REPORT Date: 3/18/93

Teacher	ID	Term	Total Classes	Max Consec Classes	Total Stud
Adragna, Joe	170401	1	1	1	3
Agrawal, Brij	120101	1	2	2	98
Aiello, David	190101	1	2	2	59
Almquist, Allen	030301	1	1	1	25
Anderson, Andy	040501	1	2	1	47
Armanasco, David	070301	1	2	2	49
Ausonio, Diane	121001	1	1	1	8
Babcock, Jim	180201	1	1	1	22
Bachofner, Felix	070201	1	1	1	22
Bartell, Nancy	110102	1	2	2	51
Bates, Dennis	040101	1	1	1	11
Bebermeyer, Robert	130104	1	1	1	28
Bell, Barbara	180301	1	2	2	70
Black, Scott	130101	1	2	2	56
Bowhay, Brooks	110901	1	1	1	7
Bowman, Dennis	030701	1	2	2	39
Brenner, Alan	190301	1	1	1	10
Bronner, David	030401	1	3	2	65
Bronson, Jack	180401	1	2	2	36
Canepa, David	170301	1	1	1	7

SCHEDULE CONFLICTS REPORT Date: 2/20/93

Student	Grade	Problem requests		Reason
DELACRUZ, A	12	000308	LAB TCH	C
ESPARZA, C	12	001003	COMP GOV	C
LONG, G	12	000201	DENTIST	C
NAPOLI, A	12	001702	SEC/MGR	C
NGUYEN, HUNG	12	001801	TRANSIT	C
		001602	TENNIS	C
		000203	HOSP AD	C
LUONG, N	12	000105	PUB HLTH	C
		001705	ELEC	C
EDWARDS, SILVIA	12	001705	ELEC	C
PRAKASH, J	12	001108	CITY PLN	C
		001209	PW ENG	C
LEMON, P	12	001110	CITY MGR	C
TAYLOR-SHAW, R	12	001003	COMP GOV	C
		001804	FLY INST	C
TRAN, K	12	001502	INT TRAN	C
KIM, BAEK MIN	12	001403	FIREFGTR	C
		001901	HOTEL	C
NETZORG, KATHRYN	12	001503	PRIV TCH	C
VO, K	12	000105	PUB HLTH	C
ROMAN, E	12	001502	INT TRAN	C
		001302	CRT RPTR	C

Monterey High School

SCHEDULE EXCEPTIONS REPORT Date: 3/18/93

Name	ID	Sched Grade	Course Request	Sched Class	Unsched Request	Unsched Alt Req
BERRING, J	032395	12	6	2	2	2
BUEHLER, J	014615	12	6	2	3	1
CLEWIS, M	008772	12	6	2	2	2
CRIVELLO, A	022469	12	6	2	3	1
DONAT, C	034670	12	6	2	3	1
HARDIN, B	026760	12	6	2	2	2
JAMARCK, S	031058	12	6	2	2	2
JONES, CHRIS	038454	12	6	2	2	2
LATA, J	020795	12	6	2	2	2
LE, HONG	038597	12	6	2	2	2
MURRAY, J	038670	12	6	2	2	2
OLIVER, M	015007	12	6	2	2	2
PARKER, G	025623	12	6	2	2	2
TILLER, J	008361	12	6	2	3	1
TOOKER, A	025643	12	6	2	3	1
TURTURICI, J	017009	12	6	2	2	2

Monterey High School

Student Free Period Report Date: 3/18/93

Name	ID	Term	Period 1	2	3	4
ADDICOTT, N	000038460	1	1			
ALCARAZ, S	000033914	1	1			
ALCARAZ, V	000033915	1	1			
ALEXANDER, K	000020065	1				1
ALLEN, S	000008783	1				1
ALTAMIRANO, M	000007185	1		1		
AQUINO, A	000031286	1	1			
ARNOLD, T	000025004	1	1			

Student free period totals:

Total school -- Career Day

	Period			
Day	1	2	3	4
F	89	56	21	55

Monterey High School

Teacher Free Period Analysis Date: 3/18/93

Teacher free period totals:

Career Day

	------Period----------			
Day	1	2	3	4
F	35	35	33	37

Monterey High School

Room Free Period Report Date: 3/18/93

Room free period totals:

Career Day

	------Period----------			
Day	1	2	3	4
F	35	33	31	33

APPENDIX C: FINAL REPORTS

Monterey High School

MASTER CLASS LIST Date: 3/17/93

1992-93

Course Number	Description	Section	Term	Per	Days	Tchr	Rm	Stud Cnt
000101	CRITICAL CARE	0001	1-1	1-1	F	Connors	1	21
		0002	1-1	4-1	F	Connors	1	18
000102	NURSING ADMINISTRATOR	0001	1-1	2-1	F	Robinson	1	26
		0002	1-1	3-1	F	Robinson	1	20
000103	NURSE PRACTITIONER	0001	1-1	1-1	F	Snow	2	24
		0002	1-1	3-1	F	Snow	2	27
000104	OBSTETRICAL NURSE	0001	1-1	2-1	F	Rivera	2	22
000105	PUBLIC HEALTH NURSE	0001	1-1	1-1	F	McPherson	3	20
000106	CHIROPRACTOR	0001	1-1	2-1	F	Sanchez	3	29
		0002	1-1	4-1	F	Guerra	3	24
000107	PUMONOLOGIST	0001	1-1	1-1	F	Morrison	4	16
000108	SPORTS MEDICINE	0001	1-1	1-1	F	Juricic	5	32
		0002	1-1	2-1	F	Juricic	5	34
		0003	1-1	3-1	F	Dauphine	5	33
		0004	1-1	4-1	F	Dauphine	5	35

Monterey High School

MASTER SCHEDULE Date: 3/17/93

1992-93

Course	Section	Days	Teacher	Rm	Stud Cnt
Career Day - Period 1					
000101 CRITICAL CARE	0001	F	W Connors	1	21
000103 NURSE PRACTITIONER	0001	F	D Snow	2	24
000105 PUBLIC HEALTH NURSE	0001	F	A McPherson	3	20
000107 PUMONOLOGIST	0001	F	J Morrison	4	16
000108 SPORTS MEDICINE	0001	F	M Juricic	5	32
000109 TRAUMA SURGEON	0001	F	C Shatney	6	28
000203 HOSPITAL ADMIN	0001	F	J Culley	7	25
000206 VETERINARIAN	0001	F	M Field	8	29
000303 PHARMACIST	0001	F	A Almquist	9	25
000304 PHYSICAL THERAPIST	0001	F	D Bronner	10	22
000405 OCEANOGRAPHER	0001	F	A Anderson	11	23
000503 NUCLEAR PHYSICIST	0001	F	X Mariuyama	12	29
000601 ACCOUNTANT/CPA	0001	F	B Jespersen	13	25
000603 REAL ESTATE	0001	F	J Mahoney	14	27
000701 ARTIST	0001	F	M Perry	15	35
000702 IMAGE/COLLEGE COUN	0001	F	F Bachofner	16	22
000801 BEAUTICIAN	0001	F	R Watts	17	35
000804 MACY'S STORE MGR	0001	F	R Hutton	18	31

CLASS ROSTER

Class: 000101-0001 CRITICAL CARE Teacher: W Connors

Meets: 1-1 1-1 F Room: 1 Students: 21

Student ID	Name	Grade
000032570	ALANIZ, M	12
000031024	AZEVEDO, K	12
000001638	BOUYER, M	12
000026546	CORTEZ, S	12
000011952	CREWS, H	12
000031155	DAVIS, T	12
000016927	DEGUZMAN, C	12
000038402	HUYNH, HIEN	12
000027217	JONES, CHRISTIE	12
000032236	KWON, A	12
000006876	LODGE, PATRICIA	12
000006869	MARTORELLA, K	12
000032647	MOAJE, G	12
000031352	PALMA, R	12
000014035	PATTERSON, K	12
000025752	PROCTOR, L	12
000031265	PUCKETT, J	12
000037803	PULA, Q	12
000038602	REAL, E	12
000009762	SHAW, S	12
000031187	VANATTA, J	12

CLASS SCHEDULE 1992-93 2/20/93

FOR: ABBOTT, E 000038473 Grade: 12

Per	Days	Class	Subject	Teacher	Room
1	F	000103-0001	NURSE PRACTITIONER	D Snow	2
2	F	001207-0002	INTERIOR DESIGNER	M Pheasant	GYM
3	F	000602-0002	BANKING/FINANCIAL SERV.	B Minearo	34
4	F	000404-0002	MARINE BIO./ANIMAL HUSB.	F Sommer	12

The following requested courses were not scheduled:

001802 AIR TRAFFIC CONTROLLER (alternate)

001301 ATTORNEY (alternate)

TEACHING SCHEDULE 1992-93 3/17/93

FOR: Aiello, David 190101

Per	Days	Class	Subject	Room
1		<open>		
2	F	001901-0001	HOTEL MANAGEMENT	48
3	F	001901-0002	HOTEL MANAGEMENT	48
4		<open>		

1992-93 SCHEDULE FOR ROOM 1 3/17/93

Per	Days	Class	Subject	Teacher
1	F	000101-0001	CRITICAL CARE	W Connors
2	F	000102-0001	NURSING ADMINISTRATOR	R Robinson
3	F	000102-0002	NURSING ADMINISTRATOR	R Robinson
4	F	000101-0002	CRITICAL CARE	W Connors

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